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Flooding: what is normal?

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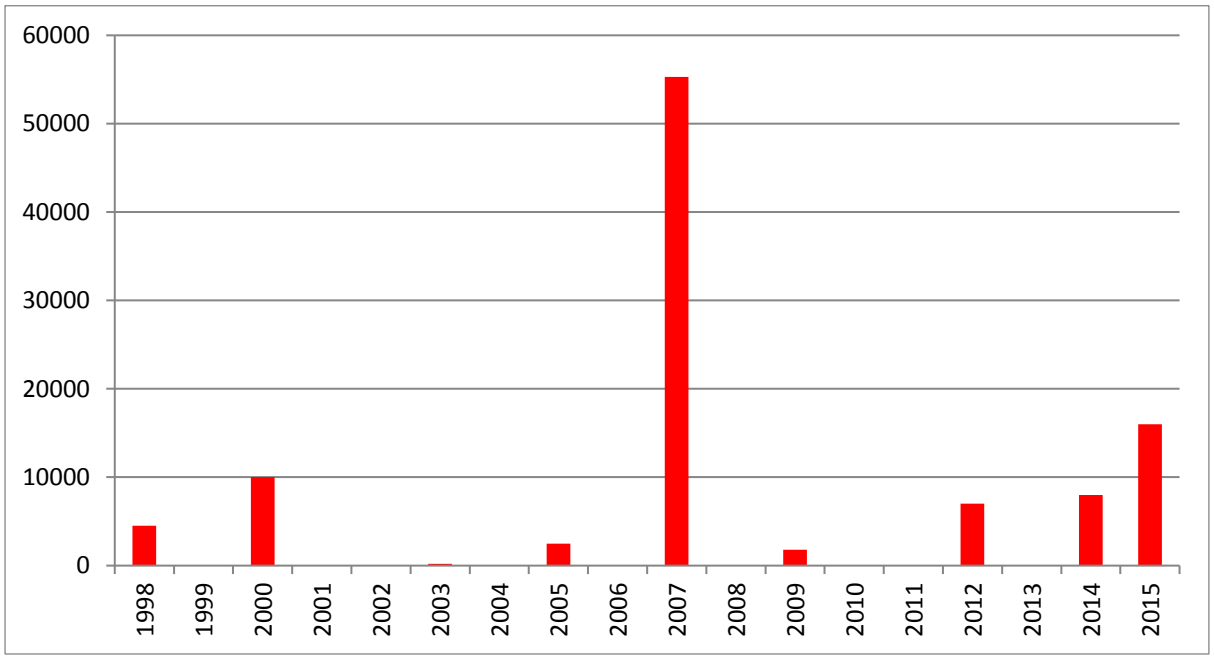
Over the last several years widespread episodes of flooding have led to extensive media coverage and national debate that at times has come to dominate the political agenda. Flooding of the Somerset Levels during the winter of 2013-14 and as a result of storms Desmond and Eva in 2016 have led to concerns over whether the UK is sufficiently resilient to flooding, whether we have correctly identified the risks we face and whether we are spending enough money on flood defences. An answer to any of these questions first requires we understand just how often we can expect damaging floods, both in specific locations and in terms of national scale aggregated losses.

Almost by definition, river flows need to be extreme to cause to flooding at specific locations, and we therefore tend to view all episodes of flooding as somewhat unprecedented. Over many years in the UK a consensus emerged amongst politicians, risk managers and the public that communities should be protected against river floods that have a 1 in 100 (i.e. 1%) chance of occurring in any given year. On average, one would expect such a flood to occur at a specific location only once in a century, and hence this event is known as the '100 year flood'. This terminology is however misleading as it implies such floods can only ever occur once in a century; it is always possible, albeit unlikely, for very rare events to occur close together simply by chance.

We estimate the magnitude of the 1% annual chance flood for particular places by analysing multi-decadal series of river flow measurements and computing the statistical distribution for extreme floods. We then use this to estimate the magnitude of the 1% annual chance event in order to design defences to protect people and property against floods up to this size. Defences can always be over-topped or fail for floods larger than the design event, i.e. those with a less than 1% annual chance of occurring, and here the UK relies on the insurance system to collectivize the losses. The insurance system also deals with the losses for surface water flooding away from main rivers and for properties built within the floodplain.

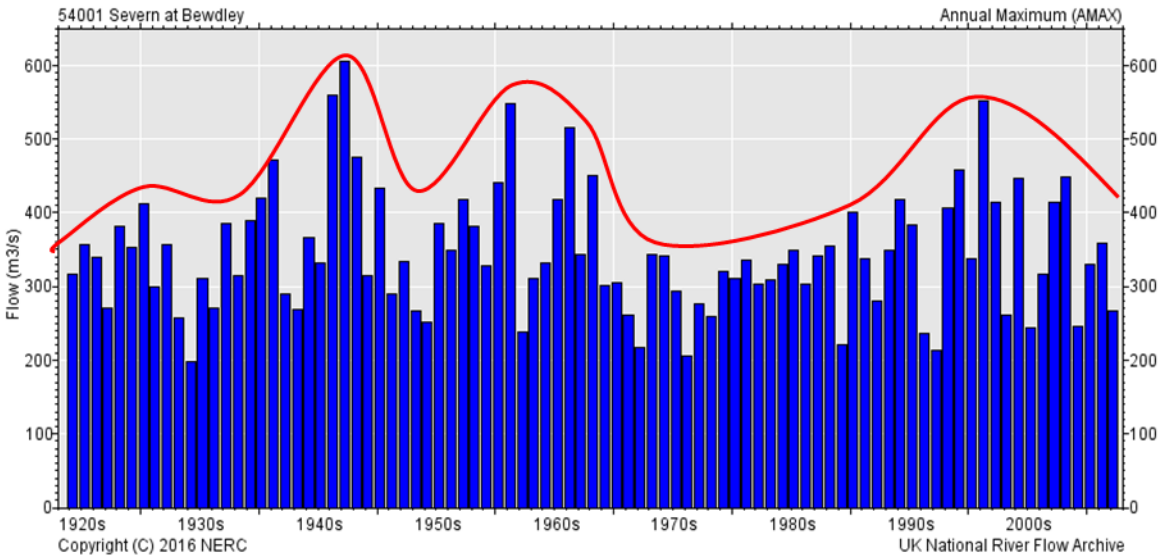
Based on the above one might conclude that floods should be a rare occurrence, yet this does not seem to accord with our recent experience. Is flooding more common now, and if so why might this be? First, it should be noted that whilst particular places should only see flooding very rarely, damaging floods will occur somewhere in the UK on an annual basis. The Figure below shows the annual total number of properties flooded in the UK from 1998 to 2015. Every year sees '100 year floods' somewhere on the UK river network, and whilst storm Desmond broke the UK 24 hour rainfall record in terms of national annual flood losses 2015 was depressingly normal. Flooding in 2015 was extreme where it occurred, absolutely terrible for those affected, but the national annual loss was not at all unusual. In fact consideration of these data shows that we can expect to see annual flood losses similar to 2013/4 and 2015/6 every 2-3 years in the UK. Moreover, despite the

'unprecedented weather' narrative of much media coverage of recent flooding, similar losses occurred in 2000, 2007 and 2012.



Annual total number of properties flooded in the UK 1998 – 2015.

Has it always been like this? Is collective memory really that short, or are there more floods now than there were? We can answer this question by looking at the data from the very small number of relatively undisturbed sites in the UK where we have really long flood records. The next Figure shows data for the size of the largest flood in each year on the River Severn at Bewdley from the 1920s to the present day. The red line shows the changing trend in these data, and this clearly highlights the presence of 'flood rich' and 'flood poor' periods. We can clearly see a period of large floods during the 1940s and 1950s and again in the 2000s, with several decades of smaller annual maximum floods in between. Such decadal variations in the frequency of extreme floods are likely driven by large scale cyclical changes in the atmosphere and ocean, but will also be affected by long term trends such as those caused by man-made climate change. What is clear is that with the benefit of hindsight we can identify the Easter 1998 floods in the Midlands as the point at which we began to enter a flood rich period that is apparently still continuing.



Largest annual floods on the River Severn at Bewdley 1920 to present day (Source: UK National River Flow Archive, http://nrfa.ceh.ac.uk/).

Decadal variability also makes it difficult to correctly estimate the magnitude of the 1% annual chance flood. The majority of our river flow measuring stations were installed in the 'flood poor' period of the 1960s and 1970s as a result of the 1963 Water Resources Act, and the data collected from this period may not be a good guide to the frequency of flooding during the 'flood rich' period we are experiencing today. Unfortunately, the obvious solution of using only the last 15 years of data to estimate our design flood magnitudes does not work well because with far fewer data points available large statistical errors can creep in.

There are two other reasons why flooding seems more common now than in the past. The first is that we have substantially increased our exposure to floods over the post-war period. Population increases since 1950 have resulted in a substantial expansion of housing and development, a significant proportion of which took place on floodplains as the land was flat and cheap to develop. Unfortunately the planning system has not been sufficiently robust in enforcing flood risk control, and whilst this situation is much improved inappropriate development in floodplains still continues. Data presented to the latest UK Climate Change Risk Assessment shows that between 2001 and 2014 250,000 homes, approx. 12% of all development, were built in areas classified as having a greater than 1 in 100 annual chance of flooding. More worryingly, since 2001 approximately 23,000 homes have been built in areas having of high risk (defined as a 1-in-30 or greater annual chance flooding). With the UK population projected to increase from 64.6 million in 2014 to 74.3 million by 2039 these trends are highly likely to continue.

Secondly, over the post-war period our vulnerability to flooding has also increased. Rising incomes have increased the assets at risk and losses are now proportionately greater. As a result resilience has reduced. We now own far more than our parents did, and consequently when flooding does occur we have more possessions that can be damaged. Economic growth will exacerbate this trend too.

In fact, it is very likely that increasing exposure and vulnerability have, to date, done at least as much to increase flood risk in the UK as changes in the magnitude and frequency of flooding that we have experienced. By definition risk is the product of the scale of the threat, the number of assets that are exposed and how vulnerable these things are to damage, so all three factors need to be taken into account when we think about flood risk. As well as increasing exposure and vulnerability, the future may also bring increases in flood hazard as a result of both natural variability, catchment alterations and man-made climate change. As the River Severn flood data indicate, the natural variability in flood climatology is large, and decadal scale cyclical variations and confounding factors within the catchment, such as land use change, will mean it may be some time before we can identify conclusively the effect of man-made climate change on the frequency of flooding. However, there are very good physical reasons to believe that warmer atmospheres will also be wetter atmospheres, and this is very likely to lead to more frequent and larger floods in the future.

In conclusion, in terms of national scale annual losses we can see that, contrary to the standard media narrative, flooding during winter 2015/6 was, by recent experience, entirely normal. At present it seems we should expect annual total flooded properties to exceed 10,000 every few years. Whether this degree of resilience is acceptable needs a wider debate; personally I don't think it is. We also need to examine openly whether the consensus of protecting against the 1% annual chance event is something we as a society are still comfortable with. At the same time scientists need to undertake further work to make sure our hazard assessments are not biased by the 'flood rich' and 'flood poor' periods in our data. Most importantly we need a more sophisticated view amongst politicians and the general public alike of how events which may be extreme in particular places can lead to levels of national scale loss that are seen much more frequently.